Comparison From Past Earthquake Scenarios

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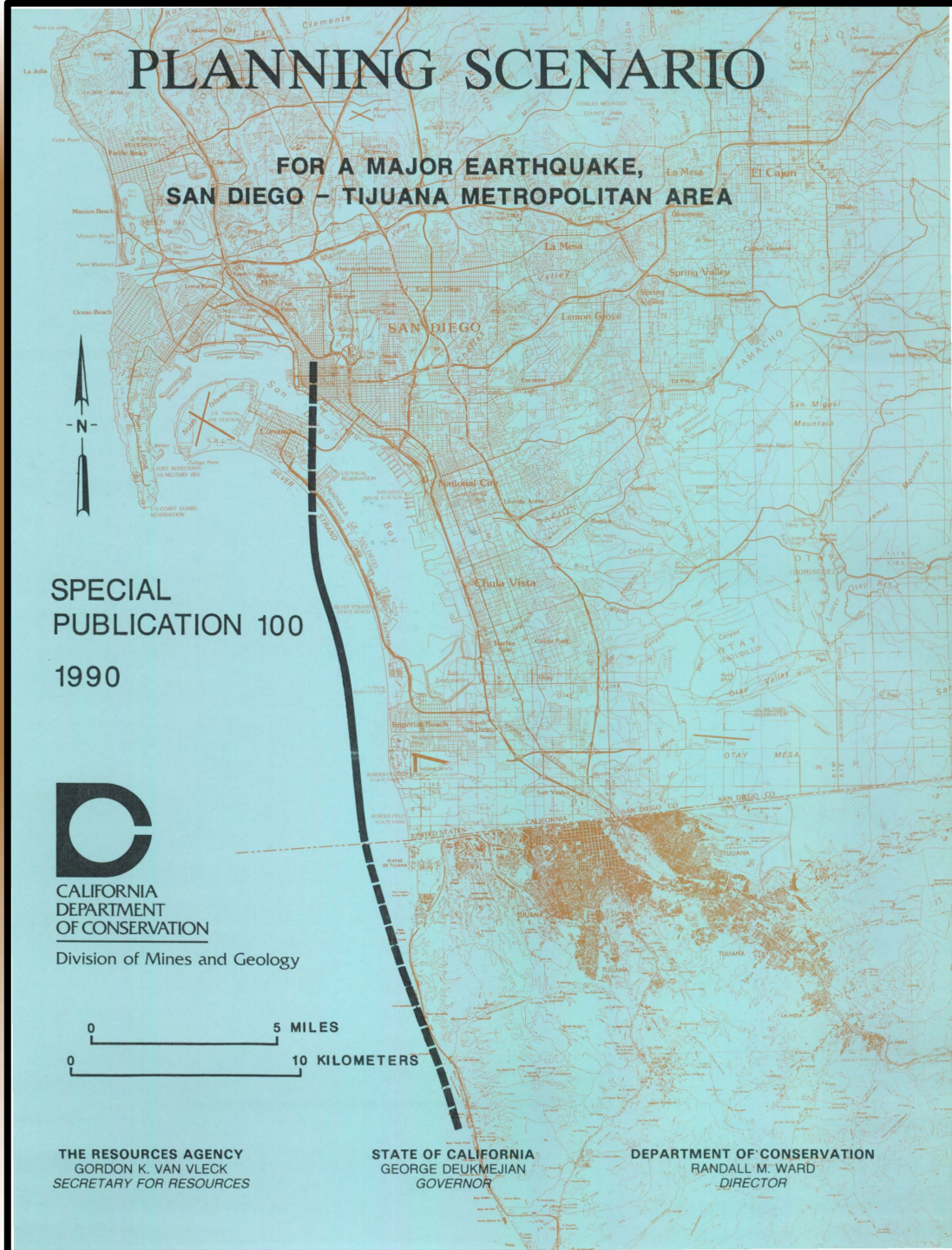
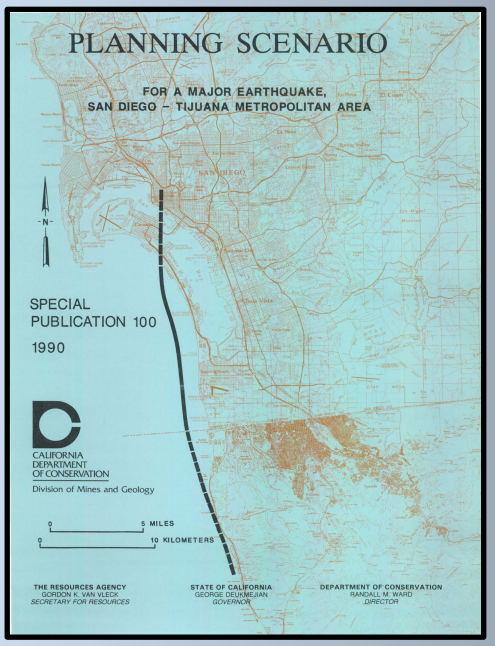
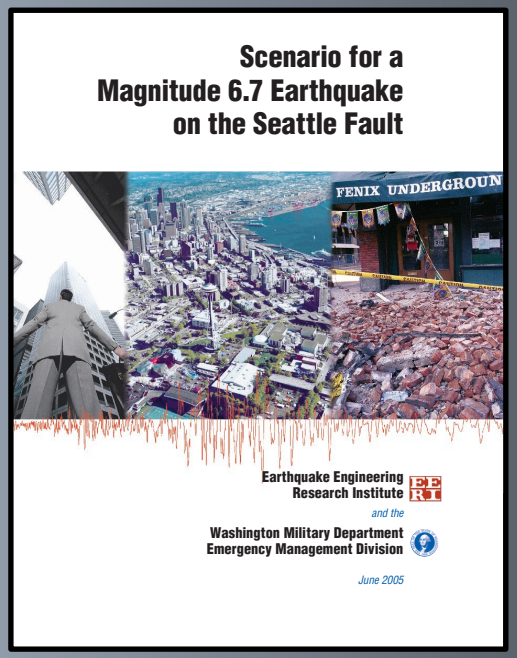
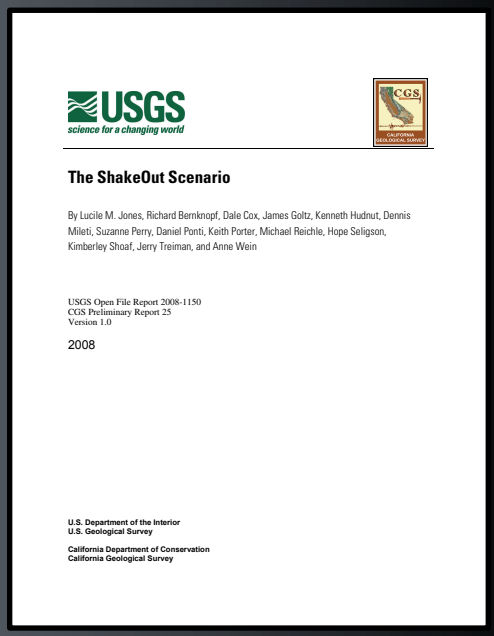
Murbach Geotech

1990 San Diego-Tijuana Earthquake Planning Scenario



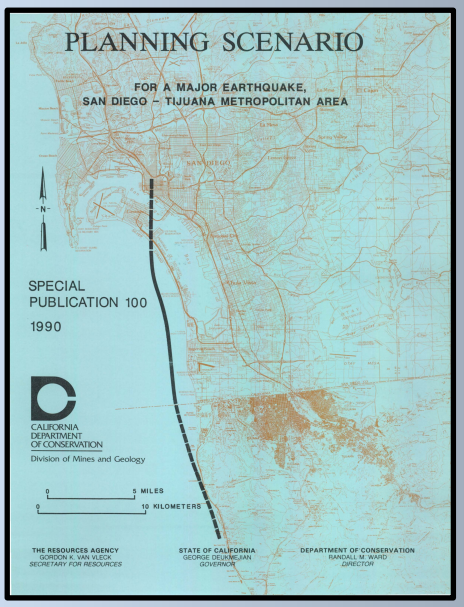


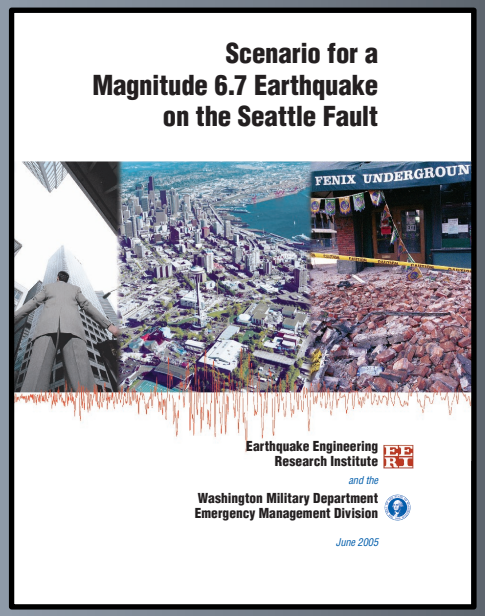


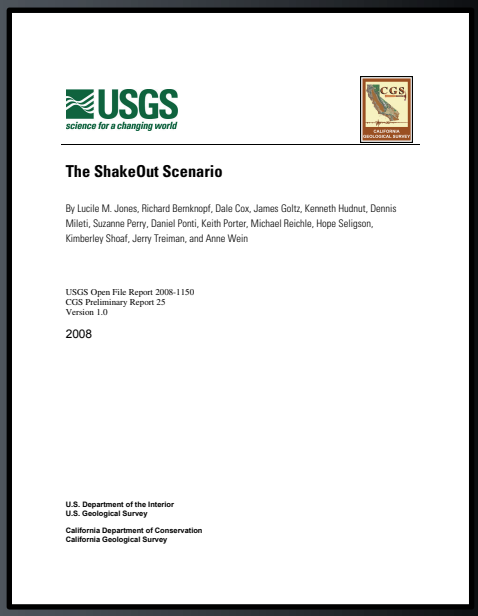


1. 1990 Planning Scenario for a Major Earthquake, San Diego-Tijuana Metropolitan Area, by California Geological Survey (CGS) Special Publication 100.
2. 2005 Scenario for a Magnitude 6.7 Earthquake on the Seattle Fault, by EERI & Washington Military Department Emergency Management Division.
3. The Shake Out Scenario – Effects of a Potential M7.8 Earthquake on the San Andreas Fault (CGS PR 25/USGS OFR 2008-1150).

Scenario	**1990 San Diego-Tijuana** (198 pages)	**2005 Seattle** (170 pages)	**2008 San Andreas Shake Out** (312 Pages)
Team:	Team of 10: Michael S. Reichle & James E. Kahle (CGS). Thomas G. Atkinson & Edwin H. Johnson. Robert A. Olson, Henry J. Lagorio, Karl V. Steinbrugge, Lloyd S. Cluff, Terence P. Haney, James E. Powers.	A 12-member project team of scientists, civil, structural, and geotechnical engineers, planners, and emergency managers.	Team of 14: Lucile M. Jones, Richard Bernknopf, Dale Cox, James Goltz, Kenneth Hudnut, Dennis Mileti, Suzanne Perry, Daniel Ponti, Keith Porter, Michael Reichle, Hope Seligson, Kimberley Shoaf, Jerry Treiman, and Anne Wein. + 300 Contributors. Experts, Teams, Panel Discussion, Workshops.







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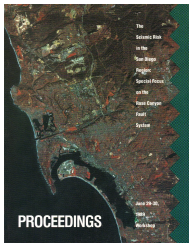
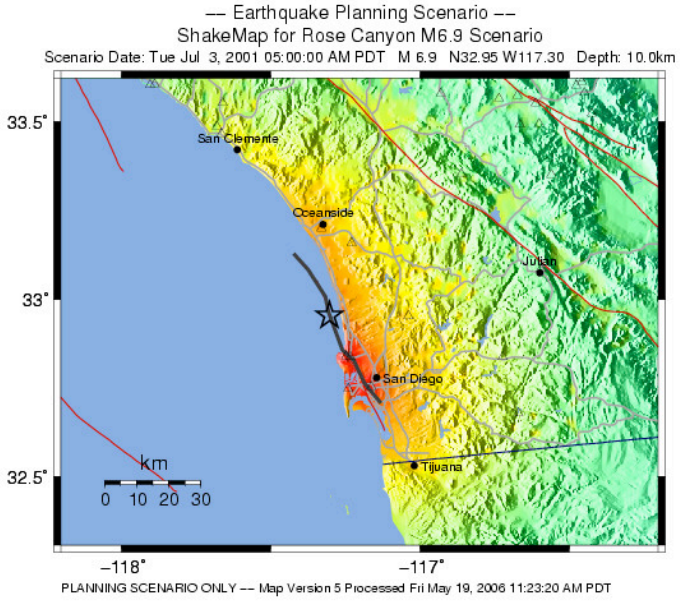
<u>Resources; Other Subsequent Local Scenarios</u>: 	This was the First specific Scenario for San Diego. *Also see The Shake Out Scenario – Effects of a Potential M7.8 Earthquake on the San Andreas Fault (CGS PR 25/USGS OFR 2008-1150). *Also see "HAZUS Scenario and Annualized Earthquake Loss Estimation for California" By Rui Chen, David M. Branum, and Chris J. Wills (CGS SR 222 -2011); includes S20 Rose Canyon M6.9 Scenario. *Also see "SCENARIO for GEOINT Table Top Exercise (TTX) - US/MEX Border" M6.9 Rose Canyon FZ; Scenario for an earthquake-based disaster impacting the US/MEX border region; GEOINT TTX [USGS 23-25 Oct. 2012 at NORTHCOM]. Total loss exceeds $825 M.	This was the First specific Scenario for Seattle. * Also see 2013 update for the "Cascadia Subduction Zone Earthquakes: A Magnitude 9.0 Earthquake Scenario."	This was the initial publication of the results of a cooperative project to examine the implications of a major earthquake in southern California. * Also see the annual Oct 16th Great S. California ShakeOut.

SCENARIO for GEOINT Table Top Exercise (TTX) - US/MEX Border

(U) BOTTOMLINE UP FRONT (BLUF). Scenario for an earthquake-based disaster impacting the US/MEX border region; GEOINT TTX [23-25 Oct. 2012 at NORTHCOM].

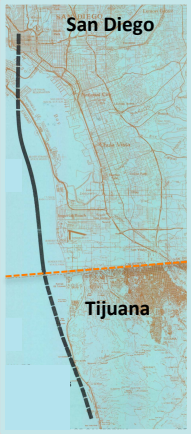
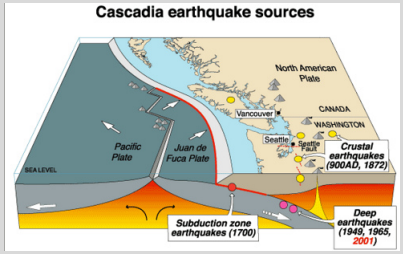
(U) SCENARIO. A magnitude 6.9 earthquake causes severe to violent shaking throughout the San Diego urban area, and strong shaking in the Tijuana urban area (see Figure 1). The earthquake results in surface fault ruptures, and shaking triggers widespread ground failure (such as from liquefaction and lateral spreading) in the surrounding port and coastal areas. Total loss exceeds $825 M, resulting from shaking damage, with significant losses from disruption of critical lifeline infrastructure such as water lines, and impacts including severe fire-following earthquake in San Diego.



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18–34	34–65	65–124	>124
PEAK VEL.(cm/s)	<0.1	0.1–1.1	1.1–3.4	3.4–8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Figure 1. USGS Scenario ShakeMap for a M 6.9 Rose Canyon – Old Town fault scenario earthquake in San Diego. Epicenter is offshore, located at the star. Surface rupture occurs in some places along the thick black line, disrupting lifeline infrastructure through La Jolla and extending southeastwards to the 'Old Town' (downtown) area.

2012 Resource that could be updated: From Dr. Ken Hudnut, USGS

Scenario	**1990 San Diego-Tijuana** (198 pages)	**2005 Seattle** (170 pages)	**2008 San Andreas Shake Out** (312 Pages)
Study Area & Population:	San Diego and Tijuana metropolitan areas: International Planning for significant damage to both. From Oceanside on the north, to Rosarito on the south, and east to Alpine and Ramona. **3.8 Million** - 2.3 million residents in San Diego County and nearly all of the approximately 1.5 million Tijuana residents.	3 Counties **3.1 Million**	Southern California: 8 Counties: Imperial, Kern, Los Angeles, Orange, Riverside, San Bernardino, San Diego, and Ventura.
Funding:	Partly funded by the U.S.-Mexico Earthquake Preparedness Project of FEMA through the Southern California Earthquake Preparedness Project. Requested by County of San Diego's Office of Disaster Preparedness to better assess the consequences of a damaging earthquake. FEMA implementation of a U.S.-Mexico bi-national agreement on earthquake planning in the border area.	EERI Endowment Fund, FEMA, and WA Military Dept Emerg. Mgmt Div.	USGS & CGS. HAZUS funding by the Governor's Office of Emergency Services. The SCEC ShakeOut Simulation Group was funded by NSF grants EAR-0623704 and OCI-0749313.
Specific Fault: 	**Silver Strand Fault of the Rose Canyon Fault Zone** (south of downtown San Diego) chosen because of its proximity to both downtown areas. At the time of his report, no fault in the metropolitan area had demonstrable Holocene (within the last 10,000 years) movement. The authors noted that a trench excavated across the Rose Canyon fault contained definite evidence of Holocene activity (Lindvall and others, 1990). Material dated at 7870 and 8300 years before present showed evidence of multiple Holocene earthquake activity. The implications of this new evidence are still being evaluated at the time of this writing. It is clear, however, that San Diego has experienced major earthquakes during the recent geologic past.	**Seattle Fault** (Northern most strand of the Seattle Fault Zone) 	**San Andreas Fault** (Southernmost 300 km (200 mi) of the San Andreas Fault, between the Salton Sea and Lake Hughes)
Magnitude Earthquake:	**M6.8**	**M6.7**	**M7.8**
Time of Day:	N/A	11:37 a.m. (worst for human casualties).	10:00 a.m. on November 13, 2008.

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Fault Rupture Length:	Fault Rupture length about 24 miles, entire Silver Strand fault, most of the scenario fault rupture is offshore. Downtown San Diego along the coast to the south, terminating approximately 16 miles south of the International border.	Fault Rupture length about 14 miles, divided into 4 segments.	Started at the southern end of the San Andreas Fault (Bombay Beach), and ruptured the fault to the northwest (Lake Hughes).
Fault Style: Average Recurrence Interval, Slip Rate, Rupture Style	**Crustal Strike-Slip.** Horizontal fault offset of up to two feet.	**Shallow Crustal Earthquake, Thrust Fault**, S up over N. Within 20 miles of surface. W-E fault rupture. Surface rupture 6.5 feet up on South side fault. South Up; North Down. 5% Estimated Probability of Occurrence in 50 Years. 1,000 Years Approx Recurrence Interval.	**Crustal Strike-Slip.** Offset as much as 9 meters (30 feet (horizontal displacement).
Ground Motions:	**Modified Mercalli Intensity IX - VIII.** This study utilized Seismic intensity, the felt effect of an earthquake at a particular place. **Short & Long period ground motions.** Ground shaking continues for 10 to 15 seconds. Frequent aftershocks continue for several weeks, with events of M5.0 or larger possible.	Peak 0.75g Spectral Accel 0.3 & 1 sec HAZUS -Computer loss-estimation modeling program.	Peak Ground Acceleration (PGA), Peak Ground Velocity (PGV), Modified Mercalli Intensity (MMI), and Spectral Accelerations at 0.3, 1.0, and 3 seconds. Includes Modified Mercalli Intensities (MMI). FEMAs loss estimation program. HAZUS + Building inventories and Expert advise with panels.
Types Ground Failure:	Earthquake-triggered ground failure, notably differential settlements and lateral spreading due to liquefaction. Seismically induced landslides (note – offshore not analyzed)	Surface fault rupture. Liquefaction-induced ground failure. Seismically induced landslides.	Surface fault rupture and offsets. Includes liquefaction, landslides, tsunamis, and seiches. Aftershocks.

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Structures Studied:	Lifelines. Transportation. Buildings. Essential Facilities. NOTE -Damage assessments for Mexican facilities or lifelines generally were not conducted. **NOTE – Study summarized: General Characteristics, Seismic Considerations, Planning Considerations, Planning Scenario.**	Lifelines. Transportation. Buildings. Essential Facilities.	Lifelines. Transportation (Infrastructure). Building damages +non-structural. Fire Losses. Essential Facilities.
Social Impacts Studied:	N/A	Economic and Business Impact. Individual and Community Impacts, Response and Recovery.	Social Science: Estimated impact on social systems. Business Interruption.
Damage Summary:	Severely disrupt water, power, sanitation, and telephone service. Homes/ businesses w/o at least 1 essential service. Several areas experience a loss of all essential services. Some services require a few weeks to restore. Extensive damage: Mission & SD Bay, W Mission Valley, Loma Portal, and Coastal areas. Heavy demand for emergency repairs. Assistance needed to affected population, and public information. Activities hampered by communications outages and transportation problems. **NOTE: The scenario does not predict detailed patterns of damage that will follow the occurrence of the postulated earthquake. Damage assessments of the postulated earthquake are generally confined to U.S. facilities and lifelines.** Includes **Modified Mercalli Intensity Summary MMI – IX.**	1,660 dead, 24,200 injured. 9,700 buildings destroyed, 29,000 buildings severely damaged and unsafe to occupy, 154,500 buildings moderately damaged with use restricted. 130 fires burn. All six major highways experience partial closures lasting months due to substantial damage, collapsed bridges. Utilities cut in areas with poor soils. Port facilities badly damaged, use restricted. Operations of businesses disrupted by collapsed supply warehouses, transportation closures, communication outages.	1,800 fatalities. The Shake Out Scenario identified five major areas of loss: Older buildings built to earlier standards. Non-structural elements and building contents that are generally unregulated. Infrastructure crossing the San Andreas Fault. Business interruption from damaged infrastructure, especially water systems. Fire following the earthquake.

Scenario	1990 San Diego-Tijuana (198 pages)	2005 Seattle (170 pages)	2008 San Andreas Shake Out (312 Pages)
Cost of Damage:	N/A	33 Billion (2004 $)	$213 Billion (2008$)
Conclusions:	This type of Scenario's Conclusions are "*General Emergency Planning Considerations*" as listed under the Damage Summary above. Here are a few important planning considerations that I summarized as Action Items: **1)** Need all emergency services to coordinate restoring essential services according to agreed upon priorities. **2)** Assistance from outside the SD area will be needed. **3)** Assistance requested for Tijuana will have to come from outside the SD affected area. **4)** Nearest major source of support will be from the LA area. **5)** Due to road damages, air transport will be the quickest means of providing support from outside the SD area. **6)** Plans/agreements should be developed for use of Miramar Naval Air Station and Brown Field as Disaster Support Areas. **7)** The use of helicopters for movement of emergency personnel and resources should be planned. **8)** Damage to the San Ysidro border crossing facilities will create serious problems. Necessary to rely on the Otay Mesa border crossing, or some other alternate crossing for an extended period.	Provides an Excellent "*Call to Action*." Raise Awareness. **Priority Recommendations** **1)** Establish an Independent State Seismic Safety Board or Commission. **2)** Implement Risk Reduction Plans for Critical Public Facilities. **3)** Retrofit of High Risk Buildings. **4)** Protect the Transportation Infrastructure. **5)** Accelerate Earthquake Hazard A Mapping and the Use of these Studies. **6)** Develop Incentives for Increased Seismic Safety. **7)** Expand Public Education Programs with Emphasis on Self-Sufficiency. **8)** Enhance the Pacific Northwest Seismographic Network. **9)** Establish an Earthquake Information Clearinghouse.	Identified the physical, social and economic consequences to enable users to identify change now, before the earthquake, to avoid catastrophic impacts after. Noted that Previous efforts to reduce losses through mitigation before the event, have been successful. Recommended more actions and policies such as: Improve the resiliency of our water delivery system. Secure non-structural items in buildings. Retrofitting of existing structures. Planning and preparedness.

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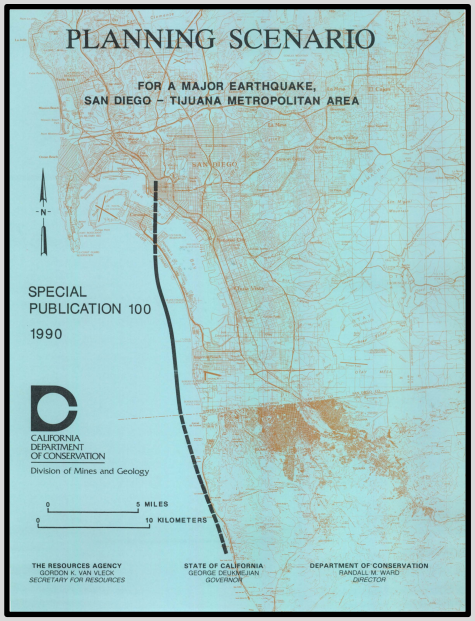
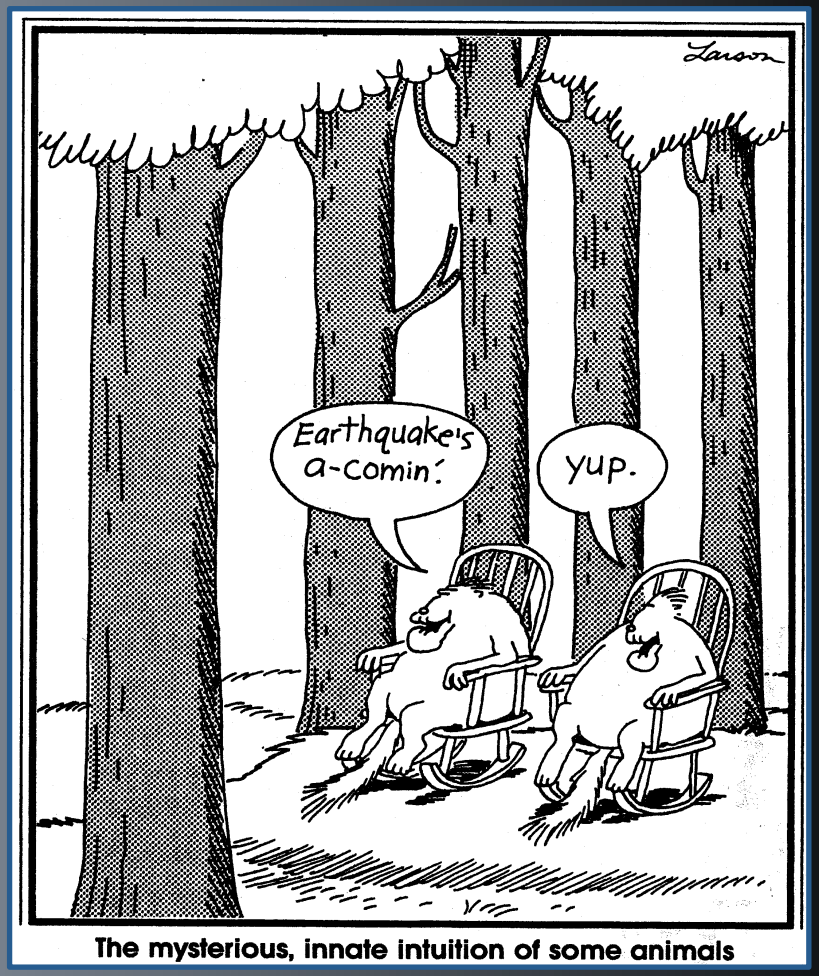
<u>Limitations of Study</u>: Not addressed	Time of Day. Estimates of Casualties. Cost Estimates for Damage. Social Impacts. Engineering Details. Graphics of vulnerable areas. Graphics of similar earthquake damage. Tsunamis and Seiches. Fires. Offshore Landslides. Hazardous Materials.	Planning style Analysis. Aftershocks. Tsunamis and Seiches. Fires.	None found at this time.
<u>Difference between Approach to Scenario Report:</u>	**1.** More of a Planners tool. **2.** Crustal Strike-Slip Fault. **3.** MMI Scale. **4.** Few Graphics.  	**1.** More Engineering Damage Details. **2.** Crustal Thrust Fault. **3.** HAZUS for Loss Estimation. **4.** Good Graphics for Technical Readers and the Public.	**1.** Main Goal to enable users to identify what they can change now before the earthquake. **2.** Excellent Outline flow: starting with **Earth Science** (Design earthquake), analyzing **Engineering** (Estimate physical damage), reviewing **Social Science** (Estimate impact on social systems), and finishing with **Policy** (Actions that could reduce losses) & Conclusions. **3.** Addressed Workshop Participants Request: Disaster scenarios that could more fully support decision-making in planning and preparedness by detailing and quantifying anticipated consequences of natural disasters. **4.** Objective was to support decision makers in their efforts to make S. California a safer community.

What do you want in the updated San Diego-Tijuana Earthquake Scenario?

Emergency response can be defined as the actions taken immediately before, during and after a disaster occurs to save lives, minimize damage to property, and enhance the effectiveness of recovery. (Mileti, 1999)